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Synopsis

A relatively simple physical test has been developed to evaluate the surface texture and particle shape characteristics of seal coat screenings. An excellent correlation has been found between the Ks value determined in the test and the coefficient of friction value. Therefore, this test may be used to control the original skid resistance value of seal coat screenings.

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HIGHWAY RESEARCH REPORT

DEVELOPMENT OF TEST FOR MEASURING ANGULARITY AND SURF[illegible] ROUGHNESS OF SEA[illegible]NGS

67-20

May, 1967

STATE OF CALIFORNIA

TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 34021

STATE OF CALIFORNIA
Department of Public Works
Division of Highways
Materials and Research Department

May 1, 1967

MR 34021

Mr. J. C. Womack
State Highway Engineer
Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A

FINAL REPORT

ON

DEVELOPMENT OF TEST

FOR MEASURING ANGULARITY AND

SURFACE ROUGHNESS OF

SEAL COAT SCREENINGS

Study made by . . . . Pavement Section

Under general direction of. . . . . E. Zube

Work supervised by. . . . . M. Nelson

Report written by . . . . M. Nelson
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Materials and Research Engineer

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SYNOPSIS

A relatively simple physical test has been developed to evaluate the surface texture and particle shape characteristics of seal coat screenings. An excellent correlation has been found between the K_s value determined in the test and the coefficient of friction value. Therefore, this test may be used to control the original skid resistance value of seal coat screenings.

INTRODUCTION

A great deal of difficulty is being experienced in performing test Method Calif. 205 with regards to the crushed count on seal coat screenings. Apparently an appreciable amount of screenings have been rejected due to not meeting the Standard Specification requirement with regard to the percentage of mechanically fractured faces even though they may possess in their natural state the characteristics desirable in seal coat work.

In the test the percentage of crushed particles is determined by selecting a representative sample of the aggregate and visually determining and counting the particles which have at least one mechanically fractured face (Test Method No. Calif. 205). The counting process from visual observation has proven quite unsatisfactory for several reasons. Due to the human element involved, considerable variance in results occurs between individual technicians and laboratories evaluating the same sample. The fact that an aggregate particle has a mechanically fractured face does not necessarily mean that it possesses the particular surface texture characteristics necessary or desirable to satisfy the particular need consistent with its intended use.

It is generally considered that two very important characteristics or qualities are desirable in connection with aggregates for use in seal coat work. One is that the aggregates have sufficient angularity characteristics to provide for interlock, and in addition have a surface texture which will provide satisfactory non-skid properties.

Although it is generally conceded that fracturing aggregate particles by mechanical crushers does provide, to a certain extent, these desirable qualities, the crushed count test as presently performed is not in itself a measure of the degree of effectiveness achieved from the crushing operation.

The rather obvious fact that the desirable qualities of angularity and ability to minimize skid hazard are provided almost entirely by the surface texture and particle shape of the aggregates, it then follows that a method for measuring and evaluating these properties would be of considerable benefit. In theorizing, the present C. K. E. test furnishes a measure of the surface capacity, including absorption of both coarse and fine aggregates. Utilizing the C. K. E. principle and isolating by satisfying the absorption demand, we have only one necessary determination which is a measure of the surface capacity, a variable depending entirely on surface texture and particle shape.

CONCLUSIONS

A quantitative test has been developed to measure angularity and surface roughness of screenings used in seal coats. The Ks value obtained in this test is related to the skid resistance of the screenings and may be used to control coefficient of friction values on original materials. The test provides a quantitative value, and may be used in place of the present method for determining the percentage of crushed particles (Test Method No. Calif. 205).

RECOMMENDATIONS

Studies on wear and polish of California screening sources indicate that screenings having an original coefficient of friction value above 0.35f will not approach our tentative minimum 0.25f during the service life of a screening seal coat. This is equivalent to a Ks value of 2.15, Fig. 5 or say 2.2 minimum value. It is, therefore, recommended that all screenings used in seal coats have a minimum Ks value of 2.2 as tested by the method described in Appendix I and that this test be substituted for the presently used crush count, Calif. 205.

TEST DEVELOPMENT AND RESULTS

A relatively simple physical test has been developed to evaluate the surface texture and particle shape characteristics of seal coat screenings. The method is outlined as follows:

The sample consists of 100 grams $\pm$ 1.0 gram of washed and dried aggregate passing a No. 3 sieve and retained on a No. 4 sieve. The sample is saturated in kerosene for ten minutes and centrifuged for 2 minutes at 400X gravity. The weight of the sample is then recorded to the nearest 0.1 gram. (This operation satisfies the absorption.) The sample is then removed from the centrifuge cup and placed in a C. K. E. test funnel. The funnel is submerged in S.A.E. #10 lubricating oil, raised immediately and allowed to drain. The difference in weights after centrifuging and after draining represents a surface factor for the screening sample. This factor, after a specific gravity correction, is designated Ks. The test method is described in detail in Appendix I.

The Ks factor has been determined for a large number of screening sources in California, and shows a range from 1.1 to 3.0. Typical screenings having varying Ks values are shown in Figure 1. Glass beads, 100% passing the No. 4 and all retained on a No. 3 sieve (B.K.H. size #6) have a Ks value of 1.0. This should be an absolute minimum Ks value since the glass beads are spherical and have no surface roughness. When increasing amounts of crushed quartz are added to glass beads, the Ks value of the combination increases in a linear manner, Table A and Figure 2. The results clearly indicate that Ks values are a measure of angularity and surface roughness.

A comparison of Ks values and crush count by Calif. No. 205 is shown in Figure 3. A trend line for most of the plotted points is shown, but it will be noted that a number of points lie above this line at high Ks and crush count values. These high values are explained on the basis that Ks measures both particle angularity and surface roughness. Further on this matter is shown in Table B and Figure 4. It will be noted that the Ks value difference between an uncrushed and crushed material is not the same for different aggregate sources.

Table C and Figure 5 show the relation between Ks and coefficient of friction values determined on laboratory test plates. The correlation is excellent and indicates that the Ks value may be used to control the original skid resistance value of seal coat screenings.

TEST METHOD PRECISION

A test series was performed in order to determine the accuracy of the proposed method for determining Ks. Five different screening samples were tested in duplicate by four different operators. The results are shown in Table D and Figure 6. The repeatability of the test by one operator is excellent; however, operator and sample variables appear to influence the final results. Figure 6 clearly shows that operators 1 and 4 consistently produced lower Ks values than 2 and 3 for five different screening sources. Also one sample, Table D, had a definitely higher standard deviation than the other four indicating sample interaction. On the basis of this study, it is recommended that three results be averaged to obtain a Ks value on any screening sample.

TABLE A

Change in Ks Value on Addition
of Crushed Quartz to Glass Beads

MATERIAL	Ks Value
Glass Beads	1.00
75% Glass Beads 25% Crushed Quartz	1.39
70% Glass Beads 30% Crushed Quartz	1.44
50% Glass Beads 50% Crushed Quartz	1.83
40% Glass Beads 60% Crushed Quartz	1.93
10% Glass Beads 90% Crushed Quartz	2.28

TABLE B

Change in Ks Value by Crushing

Chart Code	Sample Number	Source	As Received		Crushed	
			Ks Value	Crush Count	Ks Value	Crush Count
A	59-909	District 03 Bear River Quartz	1.70	0	2.40	100
B	60-579	District 02 Sandy Gravel	1.75	0	3.00	100
C	59-1949	District 02 Volcanic Material	1.91	0	2.80	100
D	57-1818	District 03 Cache Creek	1.92	8	2.81	98
E	60-831	District 01 Elk Creek	1.98	0	2.47	100

TABLE C

RELATION BETWEEN SURFACE CONSTANT-Ks AND COEFFICIENT OF FRICTION OF LABORATORY PREPARED TEST PLATES

Material	Ks Value	Coefficient of Friction f*
Glass Beads	1.00	0.16
Screenings	1.58	0.28
"	1.90	0.32
"	1.98	0.31
"	2.02	0.32
"	2.20	0.35
"	2.20	0.37
"	2.24	0.37
"	2.28	0.39
"	2.40	0.375
"	2.50	0.39
"	2.52	0.39
"	2.58	0.40
"	2.64	0.39
"	2.66	0.38
"	2.68	0.385
"	2.70	0.40
"	2.72	0.40
"	2.74	0.41
"	2.76	0.395
"	2.78	0.385
"	2.82	0.38
"	2.88	0.39
"	2.90	0.385
"	2.90	0.41
"	2.92	0.40
"	2.92	0.405
"	2.96	0.405
"	2.96	0.395
"	2.98	0.405
"	2.98	0.38
"	2.99	0.39
"	2.99	0.39
"	3.00	0.40
"	3.00	0.395
"	3.00	0.405

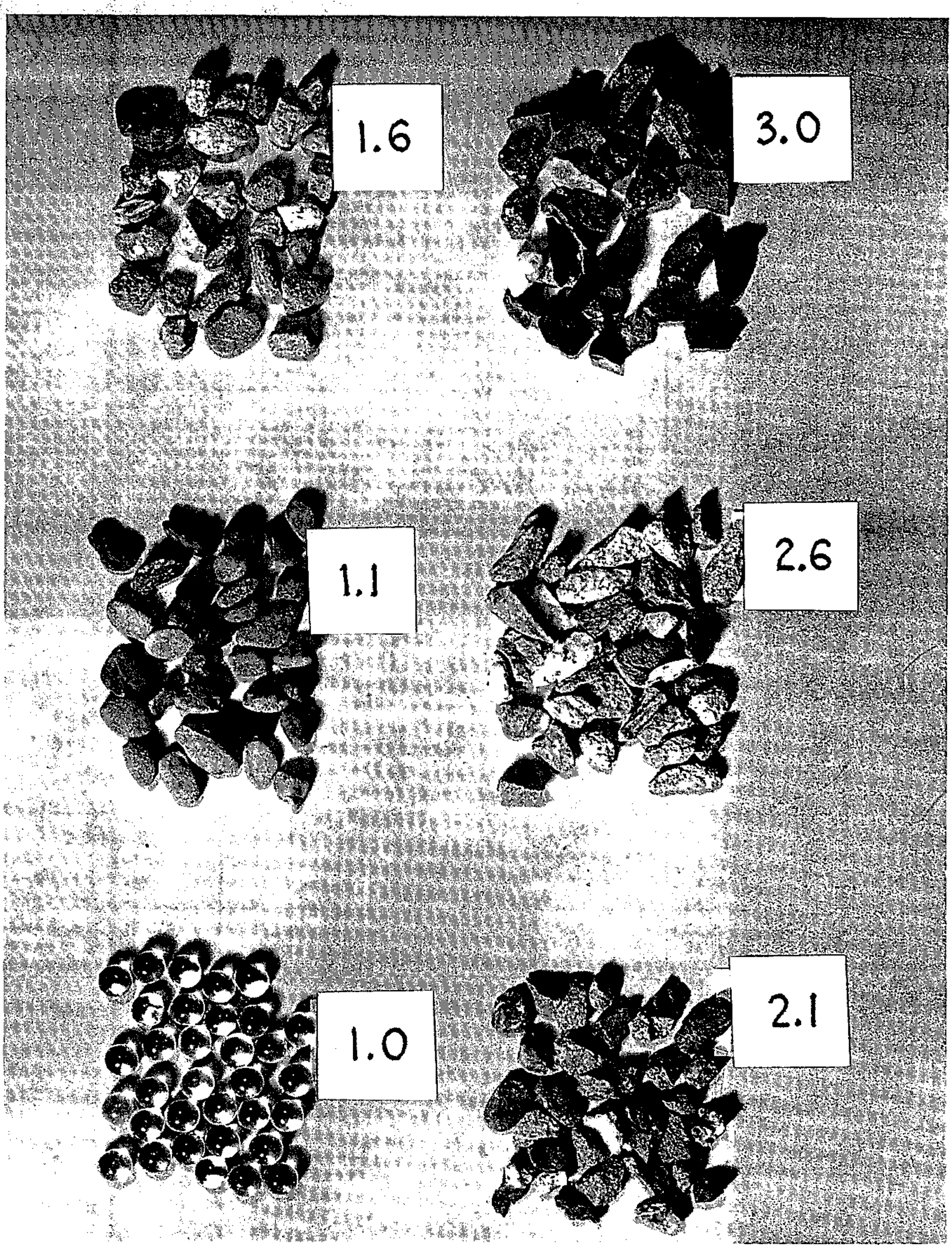
*Coefficient of Friction Values Determined at 50 mi./hr. With Wet Pavement, Smooth Tires and Locked Wheels. Tests Performed on Laboratory Prepared Screening Test Plates.

TABLE D

STANDARD DEVIATION FOR REPRODUCIBILITY AMONG OPERATORS
FOR SURFACE ROUGHNESS Ks VALUE

	Sample 60-719		Sample 60-710		Sample 61-574		Sample 61-509		Sample 61-516	
Operator	Test Results	Mean $\underline{X}$	Test Results	Mean $\underline{X}$	Test Results	Mean $\underline{X}$	Test Results	Mean $\underline{X}$	Test Results	Mean $\underline{X}$
1	1.7 1.7	1.70	1.4 1.5	1.45	2.6 2.4	2.50	1.7 1.7	1.70	2.1 2.1	2.10
2	1.8 1.9	1.85	1.9 1.8	1.85	2.8 2.5	2.65	1.9 1.9	1.90	2.4 2.4	2.40
3	1.7 1.7	1.70	2.1 1.8	1.95	2.7 2.8	2.75	2.0 2.0	2.00	2.3 2.4	2.35
4	1.5 1.5	1.50	1.8 1.8	1.80	2.6 2.7	2.65	1.8 1.8	1.80	2.3 2.2	2.25
$\overline{X}$		1.69		1.76		2.64		1.85		2.28
n		3		3		3		3		3
Standard Deviation		.144		.219		.103		.130		.132

Average Standard Deviation = .15



SURFACE CONSTANT K_S VALUES FOR GLASS BEADS AND VARIOUS SCREENINGS

Figure 1

CHANGE IN K_S VALUE ON ADDITION OF CRUSHED QUARTZ TO GLASS BEADS

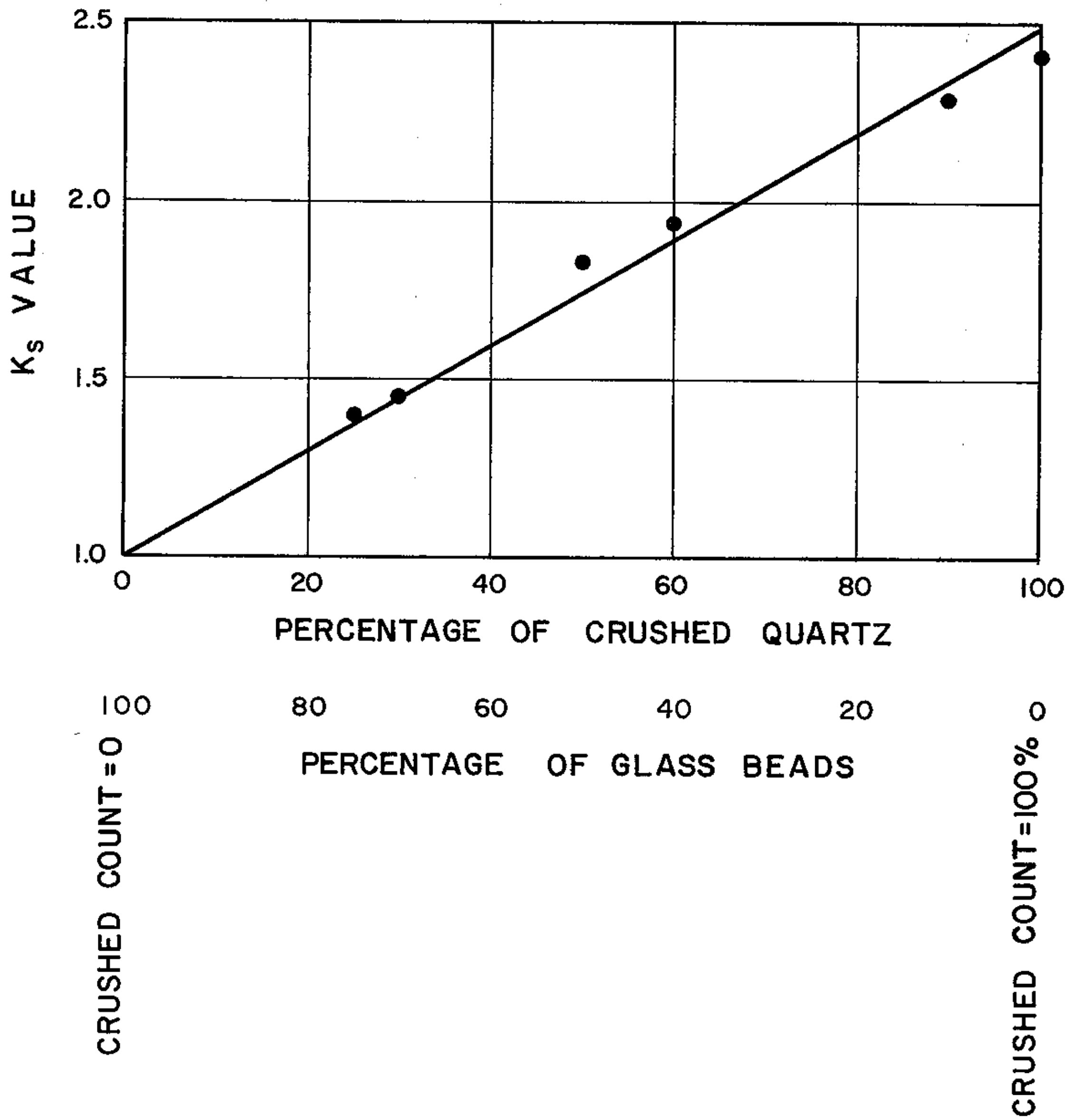


Figure 2

RELATION BETWEEN SURFACE CONSTANT K_S AND PERCENT CRUSHED COUNT

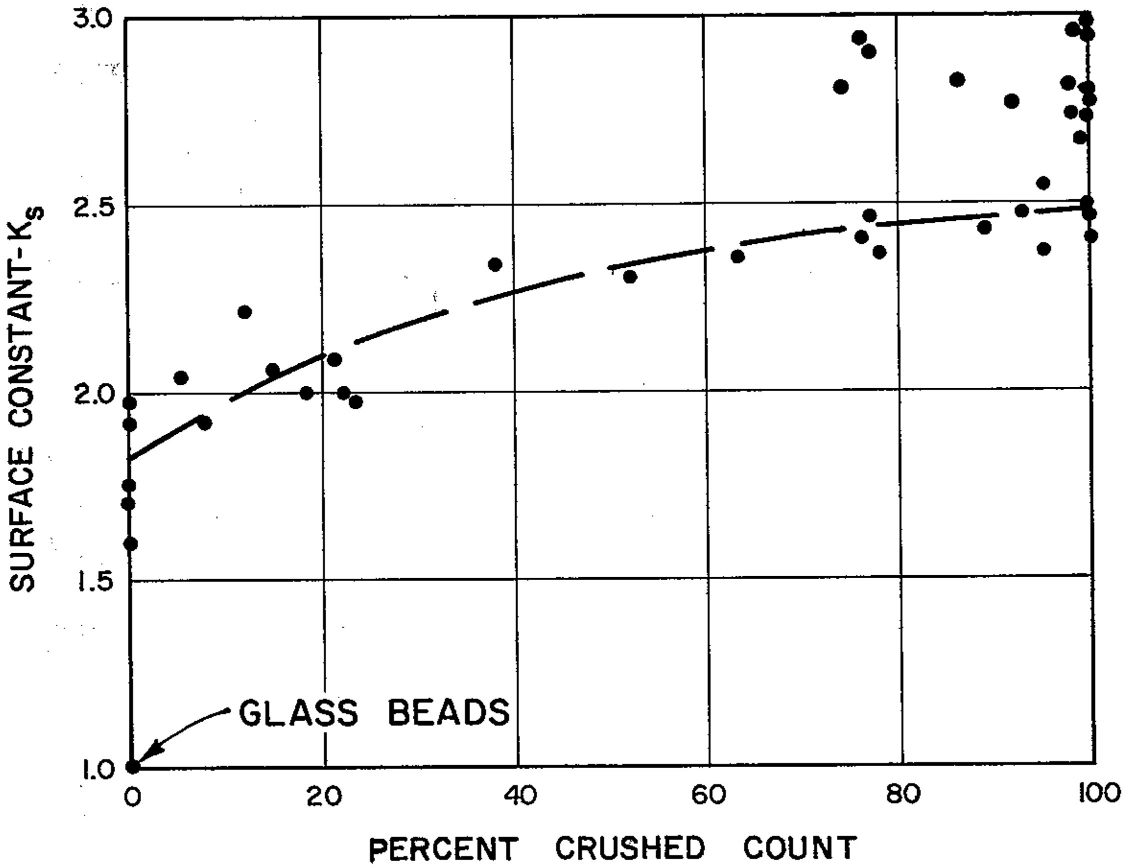


Figure 3

CHANGE IN K_S VALUE BY CRUSHING

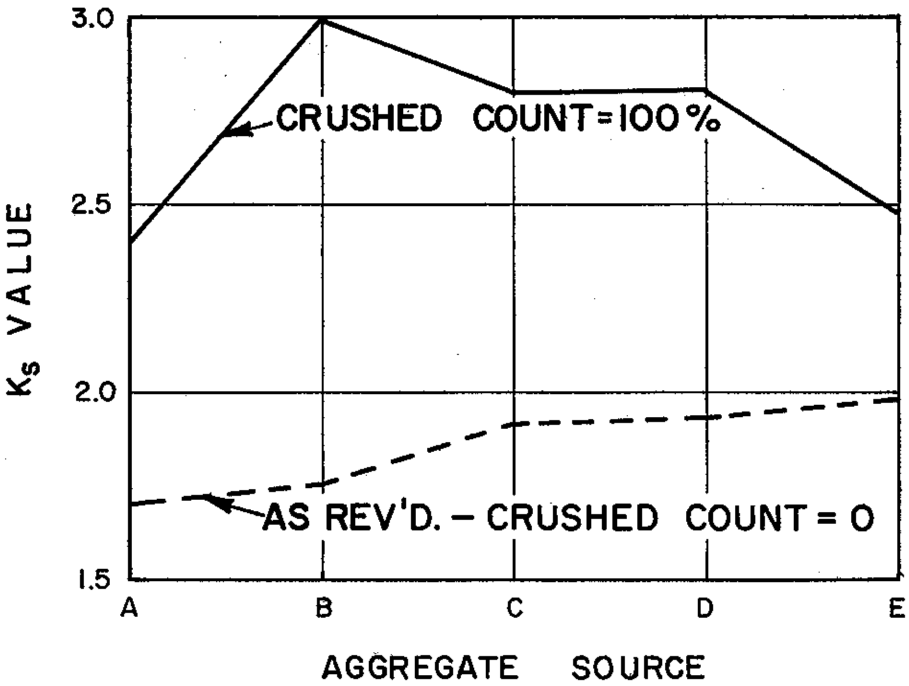
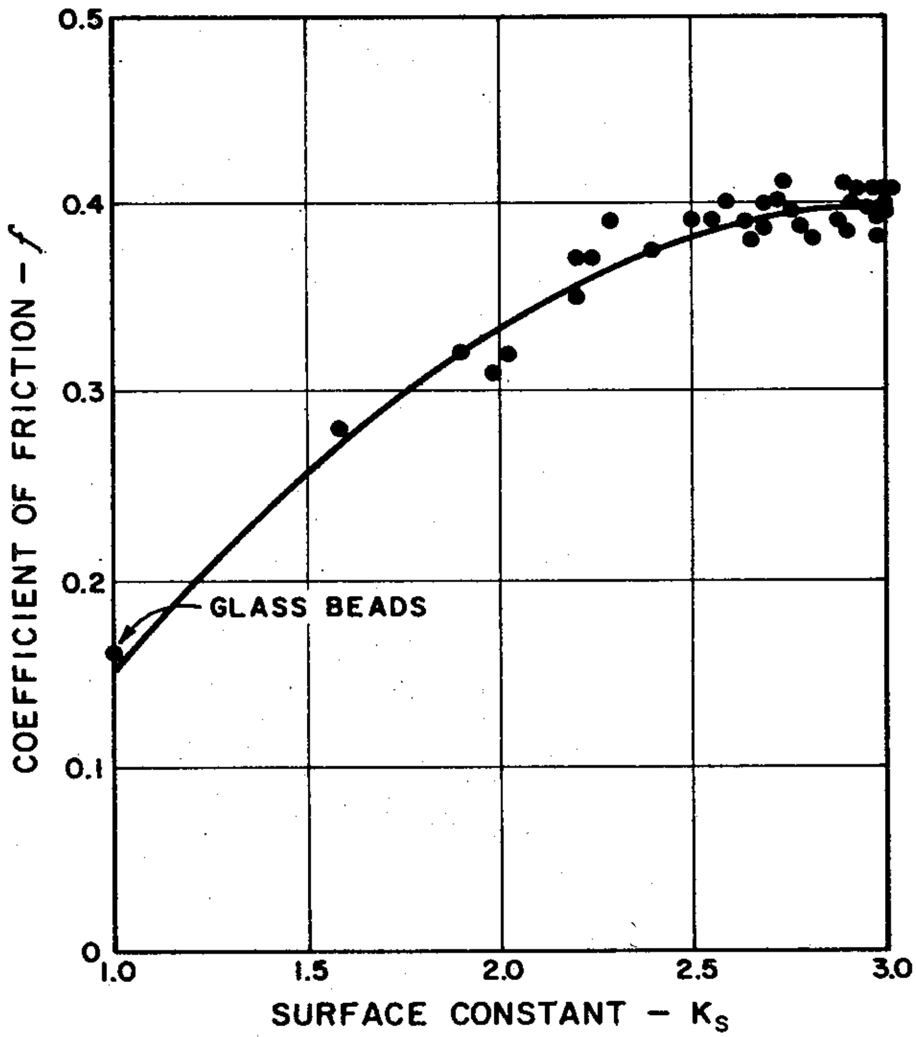


Figure 4

RELATION BETWEEN SURFACE CONSTANT K_S AND COEFFICIENT OF FRICTION OF LABORATORY PREPARED TEST PLATES.



COEFFICIENT OF FRICTION VALUES DETERMINED AT 50 MI/HR. WITH WET PAVEMENT, SMOOTH TIRES AND LOCKED WHEELS. TESTS PERFORMED ON LABORATORY PREPARED TEST PLATES.

Figure 5

VARIATION BETWEEN OPERATORS IN THE DETERMINATION OF THE K_s VALUE ON DIFFERENT SCREENING SOURCES

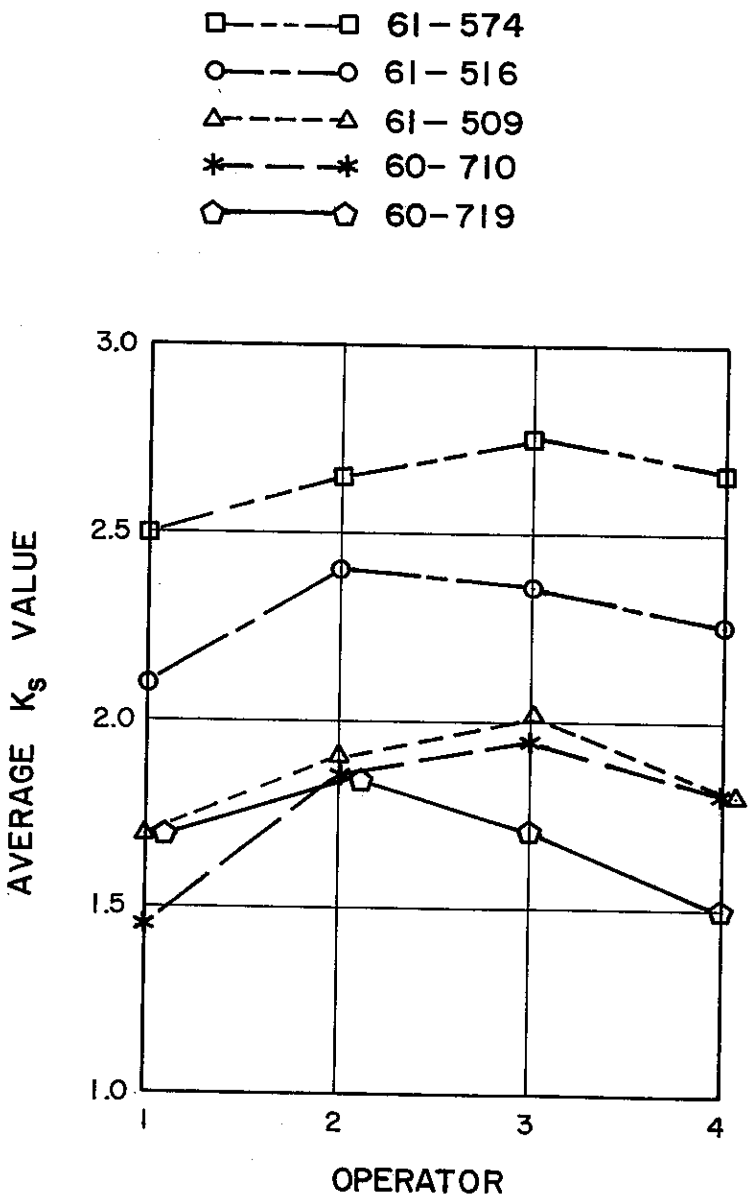


Figure 6

APPENDEX I

METHOD OF TEST FOR ANGULARITY AND SURFACE ROUGHNESS OF SCREENINGS

SCOPE

The test furnishes a measure of the surface capacity as it is affected by surface texture and particle shape characteristics.

PROCEDURE

A. Apparatus

1. Centrifuge (hand or power driven) capable of exerting a force of 400 times gravity (400G) on a 100 gram sample

   Required RPM of centrifuge head =

$$\sqrt{\frac{14,000,000}{r}}$$

   Where r = radius in inches to center of gravity of sample.

2. Centrifuge cups 2-13/16" in height and 2-1/16" in diameter complete with perforated brass plate, .031" thick with a minimum of 100 holes, .062" in diameter, per square inch.

3. Torsion balance, 500 g. capacity ± 0.1 g. accuracy.

4. Metal funnels, top diameter 3-1/2", height 4-1/2", orifice 1/2", with a piece of No. 10 sieve soldered to the bottom of the opening.

5. Glass beakers (1,500 ml.)

6. Timer with sweep second hand.

7. 140°F. oven.

8. Hot plate or 230° oven.

9. Small drain pans approximately 5" in diameter by 1" deep.

B. Materials

1. Kerosene.

2. S.A.E. No. 10 lubricating oil.

3. Filter paper, Eaton-Dikeman Co. size 5½ cm. No. 611

C. Test Record Form

Use work form T-302 for recording test data.

D. Preparation of test sample.

Screen sufficient material to obtain approximately 100 g. of aggregate passing a No. 3 sieve and retained on a No. 4 sieve. Wash this sample clean, dry thoroughly and allow to cool.

E. Tests and calculations

1. Nomenclature

a. Ks = a factor arrived at by subtracting the weight of the test sample after soaking in kerosene and centrifuging from the weight after submerging in the lubricating oil and draining.

b. Ks corrected - the factor Ks corrected for specific gravity of the aggregate.

2. Procedure for Ks

a. Weight to the nearest 0.1 gms. 100 gms. ± 1.0 gm. of the washed and dried test sample.

b. Place sample in tared centrifuge cup and submerge sample and cup in a beaker of kerosene for 10 minutes.

c. Remove sample and cup from kerosene and centrifuge for 2 minutes at 400 times gravity (400 G).

d. Remove from centrifuge and re-weigh to the nearest 0.1 gm. Subtract original weight and record the difference as grams of kerosene retained.

e. Immediately after obtaining the weight of kerosene retained, remove the sample from the cup and place in a funnel (standard C.K.E. test funnel) and submerge sample and funnel in a beaker of S.A.E. No. 10 lubricating oil, raise immediately and allow to drain for 2 minutes.

f. Sample and funnel are then placed in a 140°F. oven for 15 minutes additional draining time.

g. Remove from oven and empty sample from funnel into a small pan 4 or 5 inches in diameter and allow to drain for 1 minute at room temperature.

h. Empty sample from drain pan into a tared container and weigh to the nearest 0.1 gm.

i. Subtract from the final weight, the weight obtained after centrifuging, and record the difference which will be designated as Ks, representing a surface constant for the particular aggregate tested.

j. If the specific gravity of the aggregate is greater than 2.70 or less than 2.60 make correction to Ks value as follows:

$$Ks \times \frac{\text{Sp. Gr. of Agg.}}{2.65} = \text{Ks corrected}$$

k. Perform the test in triplicate and average the results.

F. Reporting of Results

Report the Ks value to nearest 0.1 gm. on Test Report Form T-374.